Peripheral Arteriosclerosis

Arterial Grafting Procedures—Indications and Results

EDWIN J. WYLIE, *M.D.*, JOSEPH S. McGUINNESS, *M.D.*, and FREDERICK M. BINKLEY, *M.D.*, San Francisco

• **Arteriosclerotic thrombotic lesions involving the arteries to the lower extremities may be conveniently grouped into three categories. Lesions of the aorta-common-iliac level (Category I) appear to be most satisfactorily treated by thromboendarterectomy. Lesions in the femoral artery (Category II) are particularly amenable to by-pass arterial grafts. Advanced lesions (Category III) involving both areas may be treated by one or the other method or a combination of both. Aortography is a necessary prerequisite in the selection of patients for operation and the determination of the method of surgical approach.**

PART II

Arteriosclerotic Arterial Occlusion

THE INCREASING AWARENESS of the segmental nature of arteriosclerotic arterial occlusion has stimulated surgical investigation of the clinical feasibility of restoring normal flow of blood to areas rendered ischemic by arteriosclerotic thrombosis. These areas include (in addition to the extremities) the brain, the myocardium, the kidneys, and the intestinal tract. Increasing success has been reported with the use of the two methods—thromboendarterectomy or arterial resection and graft—that are currently employed to reconstitute a normally functioning vessel at the site of an arteriosclerotic arterial occlusion.

Thromboendarterectomy, first reported by Dos Santos in 1947,[1] is an operation designed to resect the diseased and thickened intima along with the associated thrombus in an occluded arterial segment, using the media and adventitia of the existing artery to create a new vessel. Grafting procedures, on the contrary, substitute an entirely new blood conduit either by interpolation of the graft after resection of the thrombosed segment or by shunting blood around the occluded segment as a "by-pass" graft. Autogenous, homogenous, and even heterologous arterial and vein grafts have been used for this purpose, as well as a variety of synthetic materials.

The purpose of this report is to describe the experiences in diagnosis and operative treatment of 172 patients with segmental arteriosclerotic occlusions upon whom direct arterial surgical operations were done to revascularize previously ischemic areas. This series included 133 thromboendarterectomies and 39 by-pass arterial grafts performed in the period subsequent to January 1951. All lesions were at one or more levels of the arterial tree, from the upper abdominal aorta to the popliteal arteries. Postoperative observation has covered periods varying from three months to six years.

From the Department of Surgery, University of California School of Medicine, San Francisco 22.

Presented before the Section on General Surgery at the 86th Annual Session of the California Medical Association, Los Angeles, April 28 to May 1, 1957.

Part I of this two-part article appeared in the August, 1957, issue of CALIFORNIA MEDICINE.

Although the final determination of operability and the choice of operation have depended upon arteriography or surgical exploration, certain generalizations concerning clinical-pathologic categories and their relation to operability can be made. The majority of arteriosclerotic lesions which caused peripheral ischemia were in the aorta or the iliac or femoral arteries. Significant arteriosclerotic obstruction in smaller arteries distal to the popliteal arteries has rarely been noted except in very old persons. Thrombosis of the subclavian and brachial arteries, although not rare, has not often caused significant ischemia in the upper extremities, except for an occasional case of complete or incomplete carotid or innominate artery thrombosis causing transient attacks of hemiplegia. Most lesions that cause cerebrovascular thrombosis are in the arteries of the brain and, because of the small arterial caliber, are unavailable for direct arterial operations.

The arterial lesions impairing arterial supply to the lower extremities can best be grouped into three broad categories, distinct with respect to symptomatology, operability, and prognosis.

The first, and most favorable category on all counts, is occlusion or stenosis of the terminal aorta and/or the common iliac arteries. Aorta-iliac thrombosis generally has appeared in younger patients; in the majority of cases in our experience the first ischemic symptoms developed before the age of 50. The early symptom of a lesion at this level is gluteal, hip or thigh claudication (often described as fatigability rather than pain). The arterial tree distal to the aorta-iliac area is free of gross evidence of

arteriosclerosis in most patients with these high level lesions. Hence, restoration of flow of blood by either form of direct arterial operation is followed in most cases by relief of all symptoms and restoration of pedal pulses. Because of our own unusually favorable experiences with thromboendarterectomy for aorta-iliac arterial occlusion (either complete or partial) in a series of 102 operations, we believe this procedure to be superior to grafting operations for segmental lesions at this level (Table 1). Immediate thrombosis of the operative segment occurred in five patients, the arterial flow becoming the same as before operation. There were five operative deaths, four of which occurred in patients in the first half

TABLE 1.—*Incidence of Local Thrombosis After Reconstructive Arterial Operations*

Diagnosis and Operation	No. of Patients	Postoperative Thrombosis	
		Early	Late
I. Simple aorta-iliac occlusion:			
Thromboendarterectomy	102	5	0
II. Superficial femoral occlusion:			
Thromboendarterectomy	17	4	4
By-pass graft (common femoral to popliteal)	18	1	3
III. Advanced aorta-iliac occlusion (with external iliac disease):			
Thromboendarterectomy (aorta, common and external iliac arteries)	14	3	1
By-pass graft (aorta to common femoral—unilateral or bilateral)	21	6	1
Total	172	19	9

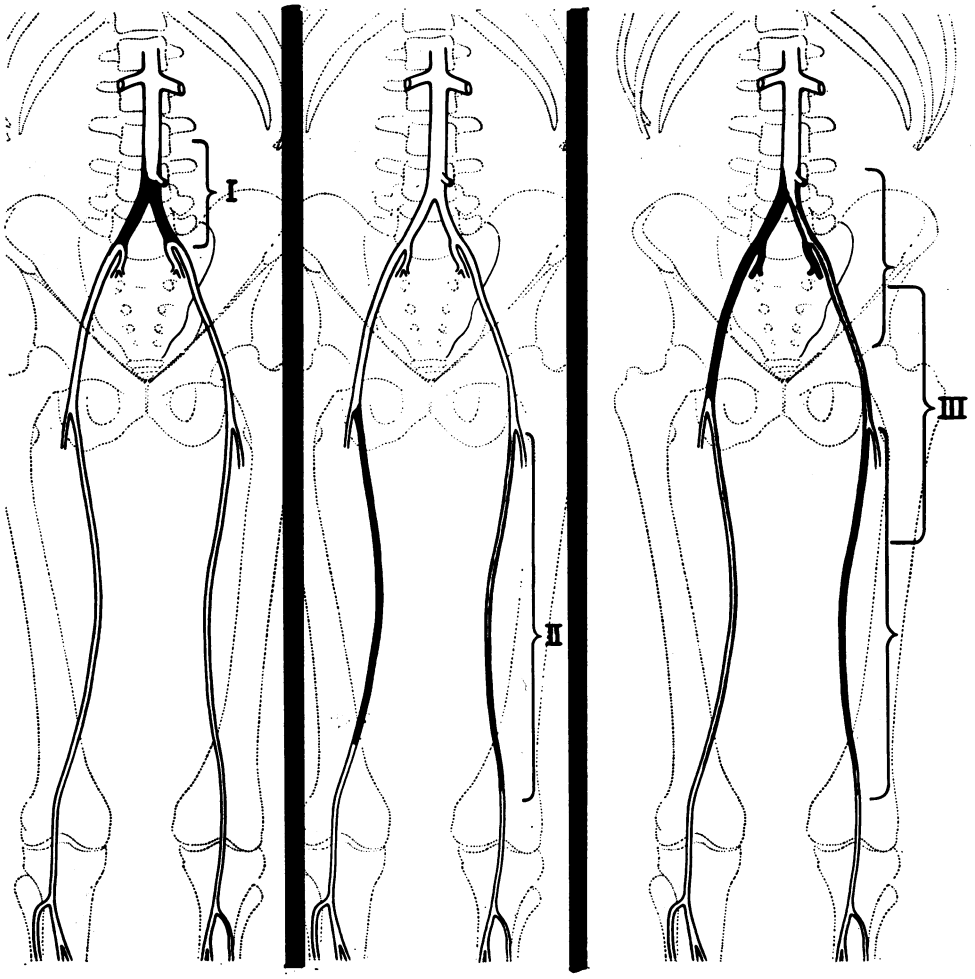

Figure 1.—Drawings from aortograms illustrating each of the three broad categories of arteriosclerotic thrombosis of arteries in the lower extremities: I. Simple aorta-common-iliac occlusion. II. Superficial femoral occlusion. III. Combined lesion with or without external iliac involvement.

of the series. There have been no instances of late thrombosis in either the segment on which endarterectomy was done or in the distal arterial tree in the patients upon whom the early patency was attained. In some cases more than six years has elapsed since operation.

The second large category of arterial obstructive lesions in the lower extremities is that of femoral artery thrombosis. Obstruction at this level tends to appear at a later age than the aorta-iliac lesions of the first category. In the present series the majority of patients noted their first symptoms after the age of 50. The predominant early symptom is calf claudi-

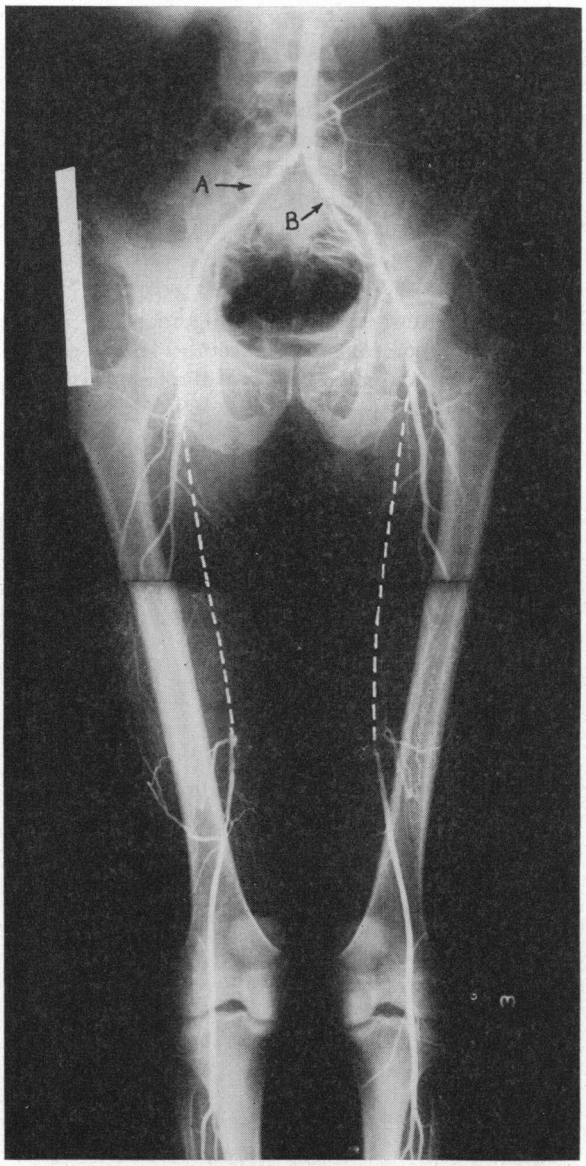

Figure 2.—Composite of serial aortograms showing arteriosclerotic stenosis of common iliac arteries, thrombosis of right hypogastric artery (*A*), stenosis of left hypogastric artery (*B*), and bilateral superficial femoral artery thrombosis (dotted lines). Note also the wide, smooth lumen of the popliteal arteries. The upper half of the illustration was photographed from the film exposed at the end of injection. The lower half was photographed from the third film in a series exposed approximately six seconds after the end of injection.

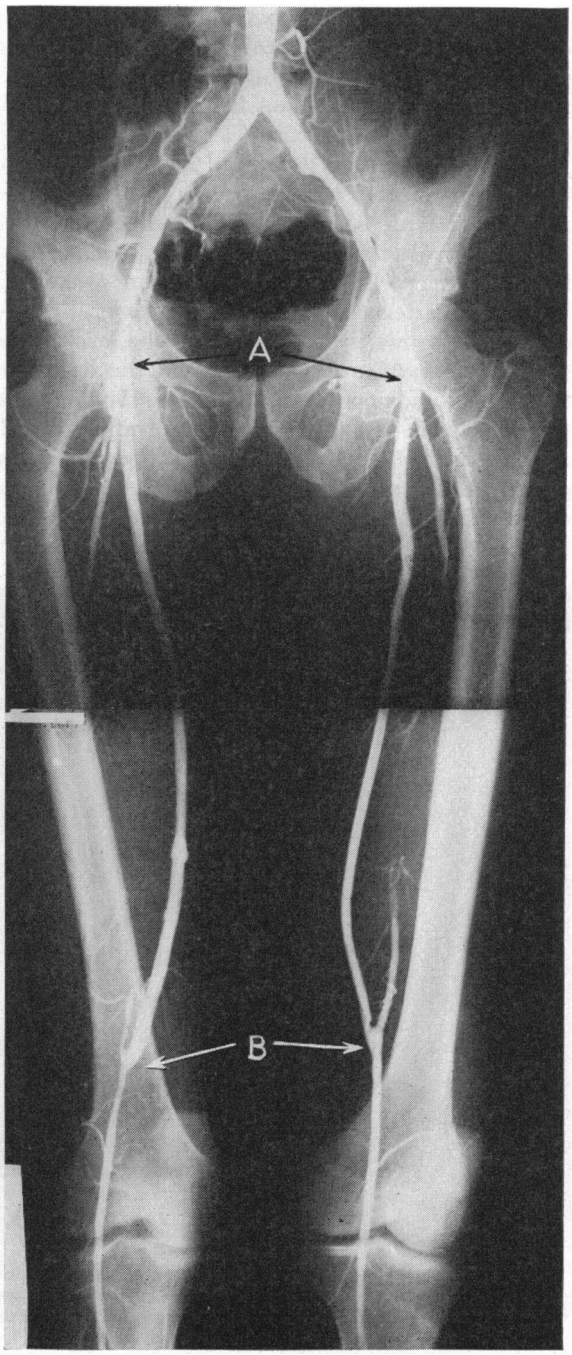

Figure 3.—Postoperative aortogram of patient shown in Figure 2. Thromboendarterectomy was carried out for the common iliac artery lesions. The superficial femoral arteries were by-passed with arterial homografts from the common femoral to popliteal arteries ($A \rightarrow B$). After operation, this patient had complete relief of all ischemic symptoms and was able to walk unlimited distances without discomfort.

cation. Manifestations of more severe ischemia than claudication in patients with a palpable common femoral pulse and absence of popliteal pulse usually have indicated the presence of additional occlusive or stenotic lesions at higher or lower levels.

Certain anatomic and pathologic considerations of femoral artery thrombosis cause this lesion to differ from aorta-iliac lesions with respect to operability and the prerequisites for carrying out a successful operation. The entire length of this artery, from the groin to the lower end of Hunter's canal, usually shows gross intimal disease about the entire arterial circumference. Occlusion, when it occurs, tends to involve the total length of the superficial femoral artery. Hence, for restoration of normal blood flow, arterial operations upon femoral artery occlusions ordinarily must begin at the level of the common femoral artery and extend the length of the thigh to the popliteal artery. Since the incidence of operative or late thrombosis of a grafted or endarterectomized arterial segment appears to be greater, the greater the length, or the smaller the caliber, of the new blood conduit, it is to be expected that this complication will appear more frequently with femoral artery operations. A further pathologic consideration is the degree of arteriosclerotic change in the distal popliteal artery.

Although total occlusion of the femoral artery ordinarily terminates just beyond Hunter's canal, luminal irregularities in the popliteal artery of sufficient degree to impair free outflow of blood are frequently present. Since it has been shown that the incidence of thrombosis of an endarterectomized or grafted arterial segment is closely related to the degree of obstruction in the outflow tract, the extent of popliteal disease distal to the occluded femoral segment is an important factor in determining the suitability of a patient in this category for arterial operation. In a small number of patients, femoral artery thrombosis is associated with complete occlusion of the contiguous popliteal artery as well. This finding usually indicates inoperability, since arterial grafting into the smaller calf arteries is rarely successful.

It is apparent from the foregoing that in the situation of femoral artery thrombosis, the smaller caliber and the greater length of the femoral artery, and the tendency in some instances for extension of disease into the popliteal artery, combine to produce a less favorable situation for direct arterial opera-

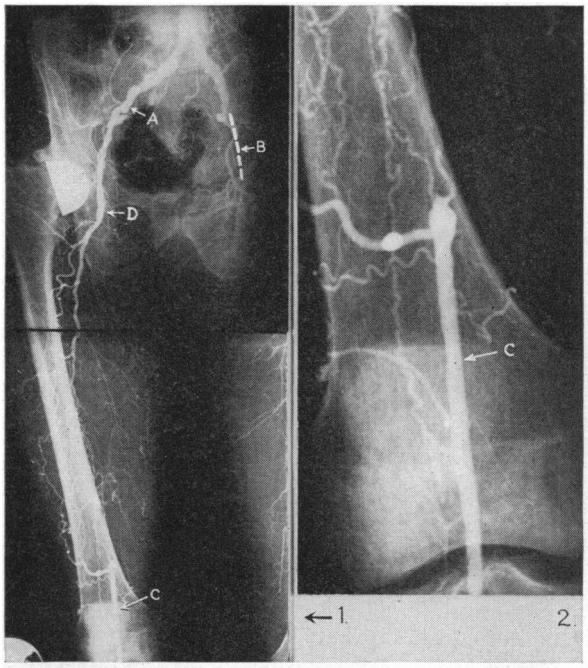

Figure 4.—Aortogram showing advanced arteriosclerotic changes in the proximal arterial tree and segmental thrombosis of the right superficial femoral artery. (View 2 is an enlargement of the popliteal artery shown in View 1.) Note that although there is occlusion of the right hypogastric artery (*A*), and of the left external iliac artery (*B*), the right common-external-iliac channel is widely patent. The open vessels above and the normal appearing popliteal artery (*C*), indicated the technical possibility of implanting a graft to by-pass the right superficial femoral artery (*D*→*C*). After operation the patient regained right pedal pulses, and a partially gangrenous toe healed rapidly.

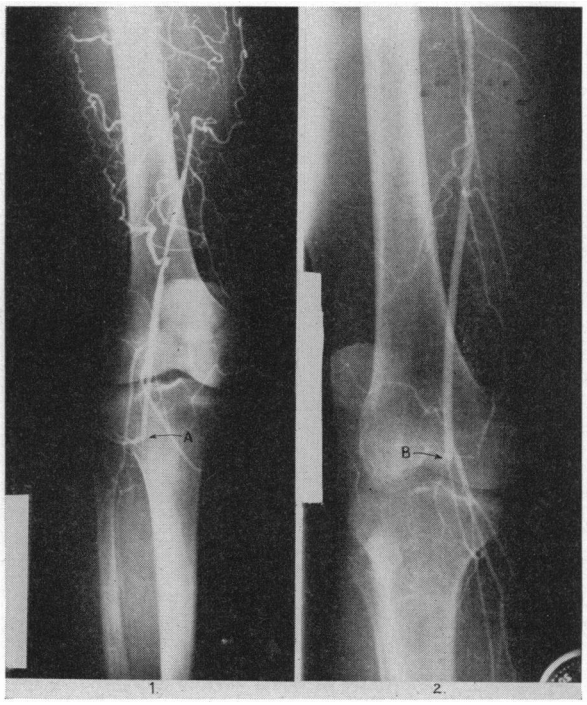

Figure 5.—Arteriographic demonstration of two forms of obstructive lesions in the distal, femoral arterial tree considered unsuitable for direct arterial operation. Note in photograph No. 1 that although the popliteal artery distal to a thrombosed femoral artery is patent in its midportion, there is occlusion at its distal end (*A*). In photograph No. 2, distal occlusion (*B*) precludes operation for this lesion.

tion than is found at higher levels. It is also apparent that arteriography assumes a major role in assessing the operability of femoral thrombosis.

Our experience with arterial operative procedures for femoral artery thrombosis is based on a series of 35 operations. In 17, thromboendarterectomy was used to reopen the occluded arterial segment. Thrombosis in the arterial segment operated upon developed in four patients immediately after operation and in four additional patients at intervals varying from one to four years after operation. Eighteen patients were treated by homograft by-passes, because of the possibility that an arterial by-passing operation might improve these results. Thrombosis developed in the graft at the time of operation in one case, but patency was established by immediate reoperation and removal of the thrombus. In 13 cases the graft has remained patent in a 12-month period of observation. Late thrombosis appeared in three cases, at seven, eight, and nine months, respectively, causing the same degree of ischemia that had existed before operation. In no case was ischemia increased beyond that originally present as a result of thrombosis of the graft. All patients initially regained at least one pedal pulse and were completely relieved of the preoperative complaint of claudication. In three patients with early gangrenous changes in one or more toes, the necrotic lesions healed rapidly. Although long-term observations are necessary for final evaluation, it is our belief that the presence of clearly segmental obstruction of the femoral artery is an indication for consideration of an arterial by-passing operation.

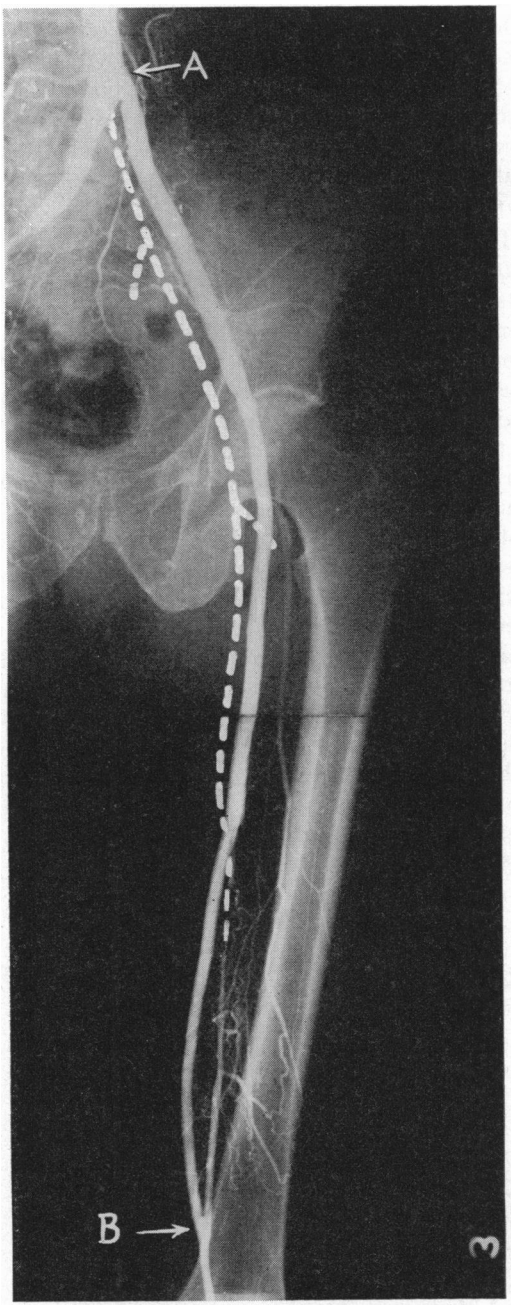

Figure 6.—Postoperative aortogram in a patient with intractable pain in the foot due to thrombosis of the entire length of the left iliac and femoral arterial system (dotted line). Preoperative demonstration by aortography of the patency of the popliteal artery and vessels distal to it indicated the technical feasibility of by-passing the occluded segment. This was accomplished by the graft shown here extending from the side of the aorta (*A*) to the side of the popliteal artery (B), with subsequent relief of all ischemic symptoms.

The third and most challenging category of arteriosclerotic disease in the lower extremity is that of multiple occlusions, or stenotic zones, involving both femoral and aorta-iliac areas. For reasons of prognostic and therapeutic significance, we have arbitrarily included in this group the aorta-common-iliac lesions that show extensive involvement of the external iliac arteries as well. This category of lesions has tended to be associated with more widespread arteriosclerotic involvement of arteries in other areas of the body. Most patients with complaints referable to advanced ischemic changes in the feet (manifested by rest pain or gangrene) have been shown by aortography to fall into this group. Although the results of operative treatment have been less encouraging for patients in the third category than in the other two, we have found that in approximately 40 per cent of such patients there exist thrombosed arterial segments and that reopening or by-passing them results in significant relief of ischemic manifestations.

For patients in this third category, when the proximal lesion is in the aorta-iliac area and if aortography shows that the external iliac arteries are uninvolved, we believe that thromboendarterectomy of the proximal lesion is indicated. This procedure alone may increase blood flow in the extremity to such a degree as to establish a satisfactory palliative result. If there are associated femoral lesions which

show patent popliteal segments distally, a second by-passing operation may even restore normal circulation to the extremity. Two patients with this combination of operable lesions had complete relief of all symptoms and restoration of pedal pulses after aorta-iliac thromboendarterectomy and bilateral femoral by-passes. Criteria for selection of operative methods for combined simple obstructive lesions at high and low levels are the same as if these lesions existed singly. One patient with extensive iliac-femoral thrombosis was successfully treated with a by-pass graft from the aorta to the popliteal artery. For external iliac thrombosis, either alone or associated with aorta-common iliac lesions, we have tended to select a by-passing method rather than thromboendarterectomy, because of the length and smaller caliber of the thrombosed segment. The higher incidence of immediate or delayed graft thrombosis for extensive grafting operations (seven of twenty-one cases) from the aorta-iliac area to one or both common femoral arteries has led us to conclude, however, that neither procedure shows a clear superiority over the other.

The most important prerequisite for determining the suitability of patients for either form of direct arterial operation is the full and accurate definition of the location and extent of the occlusive lesions by preoperative arteriography. We are not in agreement with observers who believe that an adequate evaluation of the extent of arterial disease can be made by clinical examination alone, or that the choice of operative method can be best determined by surgical exploration. The adoption of this policy would have led, in our experience, to overlooking significant but not clinically demonstrable associated arterial lesions in numerous patients, and to subjecting many others (who have been found by arteriography to have inoperable lesions) to needless and hazardous exploratory operations. The highest level to which the great majority of complete or nearly complete arteriosclerotic occlusions may extend is the abdominal aorta at the level of the renal arteries. At present the lower extent of operability is the distal popliteal artery. Hence, the portion of the arterial tree that should be demonstrated with accuracy extends from above the renal arteries to just below the popliteal arteries. This objective is best accomplished by aortography. Full-length films (36 inches) and multiple exposures are taken, using a sufficient volume and concentration of radiopaque media to fill the arterial tree, distal as well as proximal to the occluded segment, when complete occlusion is present.

In the three categories described in the foregoing, 350 translumbar aortograms were made to visualize arteriosclerotic obstructive lesions. The complications of aortography were: Transient depression of renal function in 12 patients, transverse myelitis in one patient (with almost complete return of neurological function within three months), and stricture of the sigmoid colon in one patient. One death occurred, which was attributed to uremia resulting from bilateral renal artery thrombosis. In only one instance was the accuracy of the arteriographic diagnosis not confirmed at operation. The morbidity statistics on aortography given here are reported to present a broader assessment of the degree of risk attached to aortography, and to place the isolated reports of serious complications of aortography in proper proportion. In our experience the diagnostic value of aortography has far outweighed the hazards. It has permitted the surgeon to determine not only the degree of operability but to select the most desirable surgical method.

384 Post Street, San Francisco 8 (Wylie).

REFERENCES

1. Dos Santos, J. C.: Sur la désobstruction des thromboses artérielles anciennes, Mém. Acad. chir., 73:409-411, 1947.